(Crop Disease and Pest Series, No. 3.)

THE

AGRICULTURAL LEDGER.

1898—No. 13.

SUGAR-CANE DISEASE.

(TRICHOSPHÆRIA SACCHARI, *Mass.*)

[*DICTIONARY OF ECONOMIC PRODUCTS, Vol. VI., Pt. II., S. 176-93.*]

An Account of the Fungal Disease attacking Sugar-cane in the West Indies, together with Remedial Measures recommended by the Authorities of the Royal Gardens, Kew. Concluding with DR. BOURNE'S *Report on the Occurrence of the Disease in the Godávari deltas.*

Other PAPERS that may be consulted:

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INTRODUCTORY.

The Government of India realising the danger of the recently discovered fungal disease in the sugar-cane of the Godávari delta and the necessity of observing every precaution, have desired that a complete Ledger be prepared on the subject. In accordance with the request, the following information has been drawn up chiefly with the aid of the *Bulletins* issued by the authorities of the Royal Gardens, Kew. The references include a general description of the disease as observed by the cultivators; Mr. Massee's reports on the two polymorphic forms of **Trichosphæria**; the remedial measures recommended by planters and experts; and, finally, the accounts of the occurrence of the blight in India.

Trichosphæria Sacchari, *Mass.*

Synonyms.—*Rind fungus. Root disease, red patch, red smut or Reed Snot* (Dutch) *the "sereh" or sugar-cane disease of Java, is referred to* COLLETOTRICHUM FALCATUM, *Went, pronounced*

SUGAR-CANE disease.

An Account of the Fungal Disease attacking

THEISSONIA SACCHARI.

to be nothing more than a condition of TRICHOSPHERIA "*Pine-apple disease of the sugar-cane,*" THIELAVIOPSIS ETHACETICUS, *Went, appears to be identical with the mycr-and micro-conidial stage of* TRICHOSPHERIA. STRUMELLA SACCHARI, *Cobb, described from Queensland.* TRULLULA SACCHARI, *Ellis and Everhart, Journ. Inst. of Jamaica*, Vol. 1, (1892), p. 159.

Synonyms.

References.

References.—*Mr. George Massee* Annals of Botany*, Vol VII., Dec. 1893, p. 515; *Dr. N. A. Cobb,† Diseases of the Sugar-cane* in *Agricultural Gazette of New South Wales*, Vol. IV., Pt. 10, p. 800, figs. 17—19, Sydney, 1893; *Kew Bulletin*, July 1893, p. 149; Dec., p. 345; March 1894, p. 81; May, p. 154; June, p. 169; Apl. and May 1895, p. 81; May and June 1896, p. 106; *Dr. F. A. F. C. Went,‡ Mededeelingen van het Proefstation, West Java*, 1893; Het *Rood Snot* (H. van Ingen Soerabaia, 1893) *Notes on Sugar-cane Diseases*, 1897.

DISTRIBUTION.

Distribution.—The sugar-cane disease which has produced such distressing results in the West Indies during the past few years is supposed to have been introduced from the East. A fungal blight had been observed in the cane plantations of India, Java, Borneo, Queensland, and New South Wales, and in 1893, simultaneously with the outbreak in the West Indies, it made its appearance in Mauritius.

India.

Australia.

Mauritius.

The cultivation and production of sugar provides subsistence for so large a proportion of the population of the Colonies that the malady was regarded as serious. The disease was first reported from Barbados by Mr. J. R. Bovell, Superintendent of the Botanical Station at Dodd's Reformatory. (*Kew Bulletin*, July, 1893, p. 150). The two forms of the blight—the rind and root stages—were observed in the same year, and the disease was still spreading in 1895. (*Kew Bulletin*, 1895, p. 87). Mr. J. H. Hart, Superintendent, Botanic Gardens, had previously forwarded samples of diseased canes from

Barbados.

* Principal Assistant (*Cryptogams*) in the Herbarium of the Royal Gardens, Kew.

† Pathologist to the Department of Agriculture, New South Wales.

‡ Professor of Botany in the University of Utrecht, formerly Director of the West Java Sugar Experimental Station.

Trinidad. In July 1894, specimens of the root disease were obtained by Mr. Sewell, in St. Vincent, and sent for examination to Kew (*Kew Bulletin*, June 1894, p. 175). News was received in 1893, that the disease had wrought terrible havoc in some of the estates in Grenada, and from Antigua it was reported that the "whole atmosphere was saturated with the spores" (*Kew Bulletin*, 1894, p. 176). Mr. C. A. Barber, F.L.S., Superintendent of Agriculture, Leeward Islands, on the 16th April 1894 reported to his Government—"The fungus (**Trichosphæria**) is our greatest enemy." In the same year, the disease appeared in British Guiana and made rapid progress through the Colony.

SUGAR-CANE DISEASE. St. Vincent. Antigua. Leeward Islands. British Guiana.

With regard to India, **Trichosphæria** was noticed on specimens of sugar-cane received from Saharanpur, North-West Provinces, in 1892 (*Kew Bulletin*, 1894, p. 83). In 1896, the canes in the district of Muzaffarnagar were badly attacked, although, strange to say, it had occurred in a mild form for two or three seasons previously without exciting much attention. Its appearance in the Godávari district of the Madras Presidency, and the remedies suggested for its eradication are discussed by Dr. Bourne whose report is appended to this article.

N.-W. Provinces. Madras. *Cons/. with p. 17.*

The disease may now be regarded as cosmopolitan, and perhaps it is not too much to assume that it is present in greater or less abundance wherever the sugar-cane is cultivated.

GENERAL DESCRIPTION.

GENERAL DESCRIPTION.

Before describing the special characters of the fungal disease which has attacked the sugar plantations of both the Old and the New World, it will be desirable to refer to the general appearance and symptoms as observed by the cultivators.

The following extracts taken from the *Kew Bulletin* afford the most authentic information on the subject and give a graphic account of the destructive effects of the disease. The first extract is taken from a Report of the Commission appointed by His Excellency the Governor of Barbados (Sir James Shaw Hay, K.C.M.G.) to enquire into and report upon the best means of destroying the borer and other pests affecting sugar-cane. (See *Kew Bulletin*, April and May 1895, p. 81.)

Report of Barbados Commission.

"In riding round the margin of a canefield, canes infected with the rind fungus are first noticed by dark red or brown marks, in one or

two joints towards the middle or base of the cane. These marks are easily distinguished from sun-burn because of their diffused character, indistinct edges, and by its being evident that they are not mere surface stains, but that the tissues beneath are affected. This "Red patch" on the canes is first noticed in July, and from October onwards gradually becomes more and more abundant up to the time of the ripening of the canes. It is by no means found only in poor-looking canes, but is often present in fine-looking plants. The red patch having made its appearance, rapidly spreads upwards and downwards, the infected area darkens in appearance, and is evidently rotten. Little black specks make their appearance, breaking from the inside to the surface of the cane, being first seen in the sleeping roots near the joints, and then at the parts of the cane between the joints, finally the cane shrivels and dries up.

Reduces the Yield of Sugar.

"The result of this disease is that canes which, if they had remained healthy, would have given a large yield of rich juice, are found to be absolutely valueless, and so far from themselves yielding sugar, their presence amongst crushed canes actually leads to a marked deterioration of the juice and of the sugar manufactured therefrom, as well as to a diminution in the quantity of the sugar obtained.

Outlook serious.

"This disease is present in probably every canefield in the island, and the total crop of 1894 is clearly found to be very seriously diminished by it. And your Commission have formed, after the most careful consideration, the very disquieting opinion that if it be left unchecked the cultivation of the sugar-cane will be rendered unprofitable, and therefore extinct in this island. With the present outlook as regards prices and production, it is evident that if sugar-cane cultivation is to remain the staple of the island, large crops must be maintained at a minimum cultivation cost, and this cannot possibly be accomplished in the presence of any serious amount of disease.

Fungus and Moth Borer.

"*Rind Fungus and Moth Borer* (Chilo saccharalis).—From the appearance it would seem that the rind disease in at all events a large number of cases started from the burrow of the Moth Borer. It would seem that in Barbados up to, say, December in each year the fungus makes an entrance into the cane at spots injured by the Moth Borer, which must, therefore, be looked upon as a very serious insect pest.

"From January onwards, however, an increasing number of canes will be found attacked by rind fungus, and without any signs of Borer whatever. From a careful examination of such canes it would appear that the attack had started from the middle or base of the cane as the fungus is most mature there, first sending out the black specks (which are spores or seeds) in those portions. These cases of canes attacked by fungus alone are very serious, because they increase with the ripening of the cane, and in March and onwards become so numerous that they constitute, we think, a large majority of the diseased canes. These canes are frequently found red from end to end and rotten or dry and shrivelled up from end to end without any sign of Borer whatever. It would appear from Mr. Massee's very comprehensive and able paper that the fungus in such instances must have effected an entrance at the ragged bases of the old leaves which have been torn or broken off. The above facts show the fungus to be a pest which can by itself and without any previous insect injury attack the cane; consequently, a pest to be dealt with in addition to any measures which might be adopted to exterminate the Moth Borer.

"*Root Fungus.*—For the present, we leave the subject of rind fungus to deal with that of "*root fungus*" so called; specimens of which have also been examined and reported upon by Mr. Massee, who determined it to be a fungus known as **Colletotrichum falcatum**, a species recently described by Dr. Went as injuring the canes at Java.

"The characteristics of this disease, as far as we have examined it, are as follows:—

(1) It was at first confined for the most part to the higher red soils of St. John, having only appeared in small patches in a very few other places, but has since spread in spots all over the island.

(2) The effect of this disease is that the canes appear to receive a check in their growth about June and July after planting; the plant dwindles down, fresh basal shoots are formed to supply the place of the dying ones, but notwithstanding this it is ultimately found that growth has been arrested and no cane formed; and if the plant be dug up, the roots are nearly all dead; and those that are still living are dotted

GENERAL DESCRIPTION.

Appearance of Diseased Canes.

Root Fungus.

Found in Java.

CHARACTERISTICS.

Canes stunted in growth.

(SUMMARY.)

over by little red spots. The dead roots are also often covered by mildew.

(3) Such canes yield practically no sugar, and the crop of a thoroughly diseased field is practically nothing.

Loss of sugar.

(4) There seems to be some resemblance between this disease and the Sereh of Java. In the latter disease we have the same retardation of growth, and shortness of joints, a greater number of dead roots, an attempt to throw out new shoots from the stool to replace those above that are dead. In Sereh, as in the St. John's disease, there is a gradual dying away of the plant after the commencement of the rainy season.

Sereh disease of Java.

The one characteristic (histological) of Sereh is the presence of a gelatinous substance, slime or gum, in the fibro-vascular bundles of the cane, giving the parts attacked a red colour.

"It has been finally decided at Kew that **Colletotrichum falcatum**, *West*, is simply one phase in the life history of **Trichosphæria Sacchari**, *Mass.*, and that the phenomena above described are the effects of that particular phase of the disease.

Selection of canes for planting.

"***Selected Cane Plants.***—It is difficult to form a decided opinion with regard to the part played by carelessly selected cane plants in propagating rind fungus. The attack appears so late in the life of the cane that it is difficult to suppose that careless selection has been the direct cause of the presence of fungus spores. It is almost equally difficult to speak with regard to the propagation of Moth Borer. This insect, as well as the fungus, appears to be more prevalent in the low than in the high lands, and it may be that the better shelter from winds in the former districts enables it to settle more effectively and prevents dispersion. On the other hand, in recent years it often happens on every estate that a larger or smaller number of cane plants fail to germinate or die off almost immediately after germination.

Use of diseased canes to be avoided.

"At all events, in some cases this is due to diseased plants, and it seems exceedingly probable that the high number of supplies on some estates has been partly due to that cause. The disease is sometimes due to the Moth Borer and sometimes due to fungus. In this connexion, an interesting experiment is recorded by a planter of this island, who planted 2,900 healthy Keni Keni plants from a

healthy field, and 2,850 Keni Keni plants selected carefully by labourers from a diseased field, trying to get only healthy plants from this field. The result was, 2,850 germinated in the first case, and only 50 germinated in the second case. One estate in the island took 80,000 plants to supply 77,000 holes. These instances, in our opinion, show one of the effects of planting diseased canes, another effect being, according to Kew experiments, to produce the root form of the disease. GENERAL DESCRIPTION

"The careful selection of plants has been urged, not only in Barbados, but in every cane-growing country where disease has led to careful investigation, and the practice of indiscriminate selection of plants has been universally condemned. There can be no doubt that while we have not sufficient evidence to warrant us in ascribing the October rind fungus to this source, it must yet be a very prolific source of all the diseases which occur in the early life of the young cane; it may possibly be the means whereby root fungus is spread, and is certainly a means of propagating the Moth Borer.

"*Change of Varieties of Sugar-canes.*—Has the continual propagation of one variety led to degeneration? There is no evidence upon this point beyond the impression left by a comparison of the Bourbon with other and with seedling varieties. Analogy teaches us that direct propagation from seed is the one most likely to maintain a vigorous species, and that although by propagation from cuttings we may gradually modify a plant to develop richness in some one respect and to maintain some one quality, yet a gradual decrease of general vitality may result, and a want of adaptation to surrounding circumstances. The production of plants from seeds possesses advantages of maintaining vitality, of adaptability to surrounding conditions, and of lending itself to the production of new qualities. Propagation from seed.

"General experience in other countries shows, on the one hand, that a change of varieties is an effectual way of combating plant diseases. Thus, Mauritius is reported to find a constant change of great value, Queensland is said to have greatly mitigated the ravages of the rust by this method, and lastly, there is an ever-increasing store of evidence of the most reliable kind to show that there are several varieties of cane in Barbados (including some seedling canes) which possess a striking, though not complete, immunity to fungoid attack. Change of varieties recommended.

GENERAL DESCRIPTION.

"The following biological consideration leads to the same view, that where one variety of plant is cultivated to the practical exclusion of all others, that all the parasites of that plant enjoy the very best conditions for their continuous propagation and increase. Or to reduce this generality to our special case, that continuing to plant the Bourbon cane is to provide a continuous supply of material for the rind fungus to grow and increase upon. Change the variety, and the parasite exists with much greater difficulty or has to change its habits.

"The fact that both the rind fungus and the root fungus are so much less liable to attack certain varieties of the cane other than Bourbon cannot fail to be a fact of immense value.

"Your Commission after very careful inquiry not only found that certain varieties of canes strongly withstand both root and rind fungus, but the record also shows that at all events in some places these varieties are very profitable to cultivate, and your Commission most strenuously advocates that the cultivation of these varieties should be extended in every direction, cultivating in each district the variety which proves most fitted for it. During the last few years, the diseases which attack the Bourbon sugar-cane have steadily increased in amount, and the history of like cases points to the belief that this increase will go on and not abate until some very serious measures are adopted; and amongst them we consider the cultivation of new varieties as one of the most promising. With the present prospect as regards price of sugar, the whole industry can only exist by the strictest economy in cultivation and manufacture; and with any serious amount of disease, cultivation must cease to be profitable. Undoubtedly, if the progress of the present disease in Barbados cannot be checked, the island is doomed to ruin. And all considerations point to the conclusion that the whole island must be ready to abandon, if necessary, the cultivation of the Bourbon variety. Your Commission recommends that every estate should be ready by having such an amount of cane varieties planted as will serve to supply, if occasion demands, a sufficiency of plants to plant the whole estate in those varieties."

Hardy varieties to be cultivated.

Bourbon variety susceptible.

Mr. W. Scott, of Mauritius, when forwarding in 1893 a case to Kew containing a quantity of sugar-canes, made the following remarks (*Kew Bulletin*, March, 1894, p. 81): "The disease, by what I have

GENERAL DESCRIPTION.

seen, appears to attack different patches in the field, and although the foliage appears healthy, the body of the cane is attacked near to the nodes with what appears to be a disease of a fungoid nature, indicated on the surface of the cane by red blotches. Where these exist the under-surface of the cane becomes dry and spongy, but does not, as far as I have been able to ascertain as yet, affect the growth of the cane. The main feature of the disease appears to be that it retards the crystallization of the juice to a very marked degree when it reaches the boiler, and even the sugar produced falls short of what might be expected."

Diminution in sugar.

The following notice taken from the *Demerara Argosy* of 16th November 1895 records the effect of the disease upon the crop in British Guiana: "To add to our distress that has hung like a thick cloud over our sugar industry for several years, the rind-fungus has appeared among the canes and is causing a loss of juice that is variously estimated at from 10 to 20 per cent. A leading planter informs us that the quality of the juice is not affected by the fungus as is the case when canes attacked by the borer are crushed along with good canes; but the quantity is seriously affected, the portion of the cane which the fungus has attacked having nothing left in it but fibre."

British Guiana.

Loss of juice.

The loss is, perhaps, underestimated in the above case, at any rate the annual deficiency in one estate was 75 per cent. In St. John's, Grenada, on many of the estates, it was computed that it would require five or six acres of canes to make a hogshead, a statement which indicates a remarkably poor yield of sugar when compared with the average outturn which is from two to three hogsheads to an acre.

Estimate of Loss.

In the Barbados the canes planted in December seem to receive a check in their growth about June or July following. In course of time the plant looks sickly and dwindles, although attempts are made by fresh basal shoots to supply the place of the dying ones. After the lapse of another six months, *i.e.*, in November and December, just as the crop is expected, no cane has been formed, growth having apparently been completely arrested (*Kew Bulletin*, 1893, p. 349).

Growth arrested.

The disease in many colonies appears to exercise discrimination in its ravages and to select one variety of cane where others are growing in the same field. The Curator of the Botanical station in the Island of Grenada was struck by the fact that in all the diseased

Discrimination of the disease.

SUGAR-CANE disease. An Account of the Fungal Disease attacking

GENERAL DISTRIBUTION.

fields only the Bourbon cane was affected; the Caledonian Queen, Striped Singapore, and Purple Transparent were at the same time healthy and vigorous.

In the Muzaffarnagar district of the North-West Provinces it was noticed that only one variety of cane, the *mertki*, was attacked; other varieties growing close by showed no sign of fungoid disease.

It has been expressed, on the other hand, that no variety of cane is immune from the attacks of this fungus provided that the health of the cane is weakened in any way, and that it suffers from insect attack or other mechanical injury to its tissues.

Mr. Harrison, of Demerara (*Kew Bulletin*, May and June 1896, p. 107), partly attributes the appearance of the disease to drought since as long as constant wet seasons prevailed the disease remained unnoticed. This gentleman also observed that it was practically common only on front lands which had been under cultivation for many years, the richer back lands being free from the blight.

REPORT ON THE SUGAR-CANE DISEASE

BY MR. MASSEE.

MR. MASSEE'S REPORT.

"The abundant supply of living material, consisting of 18 large canes, illustrating every stage of the disease, sent to Kew for investigation by Mr. Bovell, from Barbados, has enabled the vexed question as to the part played by fungi in connexion with the sugar-cane disease to be conclusively settled.

* * * * *

"Microscopic examination showed the presence of the fungus in every cane, but in some instances, owing to the absence of fruit, its presence could not be detected by the naked eye.

"Only one fungus—an undescribed species of **Trichosphæria**—was found on the canes. The idea entertained by some planters that more than one fungus is connected with the disease, probably arises from the fact that the **Trichosphæria** has at least three distinct forms of fruit, very different in general appearance, and whose development depends on the relative vitality of the canes.

"Further experiments showed that *fully developed* leaves and stems cannot be infected on an unbroken surface; nevertheless, when the

* *Kew Bulletin*, July 1893, p. 150.

surface is broken, infection is readily effected. A cane about 1½ inches diameter was inoculated by cutting a deep slit and introducing mycelium from a pure culture of the conidia; in sixteen days the cane was split at this point, and the central portion was found to be coloured red for a distance of 3 inches, and the mycelium had extended even beyond that distance, the microscope showed the presence of the dark olive conidia formed in tissues away from the light. Infection also readily takes place at points where lateral branches have been broken off.

NO MARKED EFFECT.

"*Summary.*—1. The experiments described above prove that the *young* leaves of the sugar-cane can be infected by the spores of **Trichosphæria** falling on an unbroken surface, and further, that the fungus acts as a true parasite, eventually killing the plant.

Summary of results.

"2. In older plants inoculation can only take place when the surface is wounded, but when an entrance through a wound is once effected the fungus acts as a destructive parasite.

"3. The frequent presence of both fungus and moth-borer or shot-borer in the same cane is explained by the above statement.

"*Stage I.*—Conidial condition, for the rapid reproduction of the species; appearing on the surface of wounded parts as a very delicate, dark-coloured velvety mass, or when old and very abundant, penetrating the internal tissue of the cane and producing a black charred appearance, due to the numerous chains of large olive-brown conidia.

Conidial form.

"*Stage II.*—Melanconium form, bursting through the cuticle of old canes in the form of minute black filaments. Often following the ravages of the 'Moth-borer' or 'Shot-borer' in dying or dead canes.

Melanconium form.

"*Stage III.*—The ascigerous form. Minute, black, hairy perithecia, present only on dead and more or less decayed portions of cane.

Ascigerous form.

"The conidia from Stage I., obtained from a pure culture, were placed on the unbroken surface of *very young* leaves of lateral shoots of a healthy sugar-cane plant growing in the Lily House, Kew Gardens; in 5 days the infected areas showed deep red blotches, and in 14 days the conidial form of the fungus was perfectly developed, the mycelium in the meantime having passed into the shoot and adjoining leaves. Soon afterwards the young infected

shoots decayed and dropped off, microscopic examination showing that the mycelium had passed into the tissues of the parent stem.

"Assuming the insect to first pierce the cane, the spores of the fungus would find a suitable place for development in the wound; hence the presence of one parasite prepares the way for another, and the combined action of the two soon ends in the destruction of the plant. Nevertheless the fungus is not entirely dependent on the previous presence of the insect, but readily finds entrance at broken points and can alone kill the cane."

ROOT DISEASE.

REPORT ON "ROOT DISEASE" OF SUGAR-CANE

BY MR. MASSEE.

"The stools of sugar-cane sent to Kew by Mr. Bovell from Barbados for the purport of ascertaining the cause of the "root disease," arrived in excellent condition for that purpose, and an examination of them demonstrates conclusively that the disease is due to a parasite fungus known as **Colletotrichum falcatum**, *West.* The fungus cannot effect an entrance through the unbroken surface of the stem of the sugar-cane. But the conidia germinate on decaying lateral shoots or the ragged base left by fallen leaves. Its entrance into the living portion is indicated by a bright red colouration of the fibro-vascular bundles, the colour subsequently extending to the ground tissue.

A parasite fungus.

"When an entrance has been effected the hyphæ spread rapidly throughout the length of the cane, and after a time the fructification ruptures the epidermis in the neighbourhood of the joints, and appears on the surface as a more or less effused black, minutely velvety patch.

Microscopic examination.

"Microscopic examination shows the velvety appearance of the fruiting patches to be due to the presence of numerous rigid, dark-coloured hairs, springing from a dense basal weft of colourless hyphæ; these latter also bear large numbers of minute, colourless conidia, or reproductive bodies. The conidia are capable of germinating the moment they are mature, and being produced quickly and readily disseminated, easily infect neighbouring plants.

"A second kind of conidia are formed on the oldest portions of mycelium present in the tissues, two or three large globose conidia

* *Kew Bulletin*, December 1893, p. 347.

Mr. Massee's report.

being frequently found on the hyphæ present in a single cell of the cane. These internal conidia can only escape when the cane in which they exist has become thoroughly decayed. The fungus, under normal conditions, attacks the above-ground portions of the cane, the "root disease" condition being a modification of the normal form, called into existence by the method of cane cultivation adopted.

"A careful examination of all the canes forwarded shows that the portion buried in the ground contains much more mycelium than that above ground, the mycelium in the root is also more mature, frequently producing enormous quantities of conidia in the cells. In some instances the root was rotten and decayed, the disintegration being effected by the fungus; nevertheless there is not the slightest evidence to favour the idea that the disease originated *after* planting. Many of the small roots contained a large quantity of mycelium, but it was evident in every case that this had passed from the stock into the root. On the other hand, everything points to the conclusion that the portions of cane used for propagation already contain the mycelium of the fungus, although its presence may not be indicated externally, and that the mycelium present in the buried portion of the cane favoured by darkness and moisture, develops at an abnormal rate, thus assuming the character of a disease, which in its intensity is foreign to the fungus when developing under normal conditions. Two additional species of fungi, not in any way connected with the disease, were common on the fading leaves of the canes; the one, a species of **Chætostroma**, the other a **Botrytis**. The last mentioned was also found on canes sent previously by Mr. Bovell, and it was suggested at the time that it might be connected with the disease. But further investigation has not in any way confirmed this; the **Botrytis** may for the future be dismissed from consideration.

The disease affects root and stem.

"The sugar-cane disease in Java, called Root Snot[9] is apparently the same thing, and it would be interesting to ascertain if this is the source from which it has been introduced into the West Indies.

"*Summary.*—The disease is caused by a parasitic fungus called **Colletotrichum falcatum**, *Went*, and the evidence points to the injudicious use of diseased canes for propagation as the cause of the injury to the crop which is now experienced.

Colletotrichum falcatum.

[9] Het *Root Snot*: Dr. Went (H. Van Ingen: Soerabaia, 1893).

PREVENTIVE MEASURES.

PREVENTIVE MEASURES.

Diseased canes to be burnt.

1. ***All diseased canes should be burnt and not allowed to decay naturally.***—The disease is indicated externally by the appearance of numerous minute upraised points just above the nodes towards the base of the cane; from these points proceed black sticky masses on the surface of the cane; these are the spores of the melanconium stage of the fungus which as soon as they are liberated are dispersed by wind and rain and in turn infect new areas. The matured conidia of this fungus are very abundant in the decayed and dead portions of the canes, hence all such should never be allowed to rot, but should be at once burnt to prevent further extension of the disease.

Healthy canes to be used for propagation.

2. ***Perfectly healthy canes should be used for propagation.***—To secure this the canes should be obtained from an area not infected with the disease. The hyphæ of the **Trichosphæria** from the old portion of the cane readily enter the "stools" or young shoots growing from it, and these shoots or tops on no account must be used even if they have an apparently sound appearance.

Rotation of crops.

3. ***The fields attacked should be planted up with other crops.***—This is a very essential point as the litter of cane leaves, etc. on the ground will be infected with the fungus, and perfectly healthy plants would be attacked if planted at once on an infected site. Mr. Bovell has tried this remedy with success.

Fungicides.

4. ***The use of fungicides.***—There is a possibility of the cut and exposed surface of the portion used for propagation being inoculated with the fungus spores. As a preventive against this cause of inoculation, the cut surfaces might be painted with a solution of Bordeaux mixture immediately on being cut, and repeated at intervals.

The conidia of the fungus will not germinate, neither will the mycelium grow in a 1 per cent. solution of cupric sulphate; but spraying with the ordinary Bordeaux solution is in all probability not practicable, other than in the case of an experimental plot, and would certainly have no beneficial effect on an infected area.

Nurse plants to be avoided.

5. ***Further precaution.***—It has been observed that the fungus causing the sugar-cane disease develops readily on the young leaves of the bamboo, the same may prove to be true of other members of the GRAMINEÆ, hence a careful search should be made for

(*Conf. Massee, Kew Bulletin, 1897, July, p. 151: Dec., p. 348.*)

such possible nurse plants, as the spores would be carried for a considerable distance by the wind. PREVENTIVE MEASURES.

The "Remedies and Recommendations" with regard to the spread of the sugar-cane disease drawn up by the Commission appointed in Barbados (*Kew Bulletin*, April and May 1895, p. 85) may be also suggestive. Recommendations of Barbados Commission.

1. That a strong central committee of planters and others who represent the interest of the Island as proprietors and attorneys, and who are favourable to remedial measures, be appointed to see that these measures are carried out.

2. That from this central committee the planters from each parish together with some from the adjoining ones, compose a sub-committee for that parish; the duties of this sub-committee being to keep the parish under a thorough inspection and to see that all measures are continually and thoroughly carried out.

3. That all plants before planting be soaked in Queensland solution * or other solution which the Island Professor of Chemistry, with the approval of the central committee, certifies to be equally efficacious.

4. That wherever deemed possible by the sub-committee the practice of spreading trash around young canes be given up; and that wherever it be resorted to only trash from a field which has been inspected by the sub-committee and declared healthy, or as healthy as possible, be employed.

5. The rotten canes on all fields diseased with rind fungus and "root fungus" should be burnt on the field, or crushed and burned as hereinbefore mentioned. In fields diseased with root fungus the stumps should be dug up, the mould shaken off, and be allowed to dry and be burned or buried.

6. That rotten canes on all fields be regularly burned during the crop. Juicy ones could be first crushed and the megass burned, the juice being boiled.

7. That the trash used as litter be taken from fields which are healthy or as healthy as can be got.

8. That each estate put such an area under the so-called hardy varieties of cane plants as will suffice to re-plant the whole of the estate in those varieties if necessary.

* One pint of carbolic acid to 100 gallons of water.

SUGAR-CANE disease. An Account of the Fungal Disease attacking

9. That when root fungus has made its appearance, ratooning for the present should be gradually given up.

10. That the cane fields be periodically inspected, with a view to cutting out canes infected with Borer or fungus, which canes should be bagged upon the spot and taken away, crushed and burned.

11. Rotation of crops should be especially resorted to in the case of root fungus.

SUGAR-CANE DISEASE IN INDIA.

OCCURRENCE IN INDIA.

Mr. W. Gollan, Superintendent, Government Botanical Gardens, North-West Provinces, in a letter to the Reporter on Economic Products, dated 7th December 1896, drew attention to the prevalence of the disease in Northern India. He wrote: "I have the honour to advise despatch per train of a parcel containing a sample of sugar-cane from the district of Muzaffarnagar attacked by a disease and should feel obliged if you would have the canes examined and inform me if you can offer any explanation as to its cause.

Muzaffarnagar, N.-W. Provinces.

"The disease declares its presence by the leaves assuming a yellowish hue, and in this early stage, if the canes are examined, slight discolouration of the tissues near some of the joints is found. When the disease has fully developed, nearly the whole of the tissues become suffused with red, then fermentation of the juices follow with the death of the plant.

"The disease has been noticed on a limited scale at Muzaffarnagar for two or three seasons past, but this is the first season it has appeared to such an extent as to call for serious notice. Infected plants are always found in groups or patches, and from this fact I should surmise that the disease is of fungoid origin."

Mr. Gollan, on the 16th January 1897, despatched another supply of the sugar-canes, and in the forwarding letter made the following remarks: "I met Mr. R. D. Kobus who was deputed by the Government of Java to collect sugar-cane in India, and from the description he gave me of the disease 'Sereh' which had proved so disastrous to sugar-cane cultivation in Java, I should say that the samples of cane I am sending you from Muzaffarnagar are attacked by the same fungoid disease.

"So far, only one variety of cane, *viz.*, the kind known as *meethi* in the Muzaffarnagar District, has been attacked; other varieties growing

clone by and under the same treatment as given to the *mottki*, have, up to the present, shown no signs of fungoid disease."

OCCURRENCE IN INDIA.

The plants were examined on their arrival and were found to have the red-spotted characters of rind fungus. Mr. Gollan was accordingly referred to the articles on **Trichosphæria Sacchari** published in various numbers of the *Kew Bulletin* during the years 1892 to 1896.

Manufacturers.

The report by Dr. Bourne on the occurrence of **Trichosphæria Sacchari** in the Godávari deltas is herewith reproduced. The report was printed by the Government of Madras with G. O. No. 127, 127A. (Revenue), dated 3rd March 1898.

From A. G. Bourne, Esq., F.R.S., *Presidency College, to the Secretary to Government, Revenue Department,—dated 28th February 1898.*

DR. BOURNE'S REPORT.

I arrived at Cocanada on Monday 21st, and spent the 22nd to 25th in examining the sugar-cane. I returned by steamer this morning and submit a report at once, as if anything can be done it should be done quickly. I have, in anticipation of the approval of Government, informed the Collector and some members of the Chamber of Commerce that the ryots should be induced by all possible means to root up the old stools, to burn all litter, to examine "tops" before planting and to plant only on land where paddy was last year.

Godavari.

The cutting and crushing is now going on and new planting will begin by the next new moon.

I think it would be desirable if Government were to call for a report as to the extent of the disease in all cane-growing districts. In such an enquiry it would, I think, be sufficient to ask whether any of the canes exhibited red spots or patches *in their flesh*. The ryots would have noticed such at the time of crushing. The damage done in the eastern delta at any rate is very great; from the forward crops which have been crushed, only half the usual yield of jaggery has been obtained; while from many still standing, much less will be obtained.

1. ***Introduction.***—My attention was drawn to this matter by letters from the Collector of the district and from Messrs. Wilson & Co. of Madras. Numbers of canes in certain localities were reported to be withering and the evil was generally ascribed to the ravages of some insects.

SUGAR-CANE disease. **An Account of the Fungal Disease attacking**

Mr. Maxwell's report.

A great variety of insects were sent to me, some perfectly harmless to the canes, others undoubtedly capable of doing damage. I do not propose to deal with these here as the total damage done by them in the gardens I have examined is infinitesimal as compared with that done by a fungoid growth.

This growth produces all the symptoms characteristic of an attack by **Trichosphæria Sacchari**, *Massee.*

Fungal origin.

This is the fungus which has recently threatened to extinguish the sugar industry in Barbados. Different stages in its life history have been known as the "root fungus," and "rind fungus," respectively. I find both stages present and great damage is being done, and unless some measures to check the progress of the disease are adopted at once, matters will go from bad to worse.

Mr. Maxwell, of Messrs. Wilson & Co., kindly secured me the services of several *gumattas*, and we visited a great number of "gardens"—as the sugar-cane plantations are there called—and interviewed the ryots. All the gardens we examined, among which were several reported to be quite healthy, showed much disease, and now that I have pointed out what the symptoms really are I gather from what I have been told that the disease is pretty widely spread along the whole coast, perhaps, even to Ganjam, and that it is no new thing this year but has been gradually coming on for some years. It is, however, only this year that the results have been sufficiently marked to cause it to have been brought to the notice of the Collector and Chamber of Commerce. It has evidently now taken a thorough hold of this district, and is likely, in my opinion, to be infinitely worse next year unless prompt and concerted measures are taken to check it.

Distribution.

Symptoms.

2. ***Symptoms.***—Canes but slightly affected, *i.e.*, only recently attacked, show no external signs of disease, but transverse sections show one or more bright red spots in one or more internodes, and if these are followed up by longitudinal sections, they appear as red streaks which branch at the nodes. It is the fibro-vascular bundles which become coloured. Such slight attacks usually occur somewhere about the middle of the length of the cane. Where the disease is more advanced the colouration extends also to the ground tissue, so that any section shows red patches. Subsequently the central portion of each red patch becomes opaque and white, and acquires a

Dr. Soltau's report.

texture like that of a "woolly" radish, the tissue is in fact dead. Where the disease is still further advanced, portions, first at the nodes and later elsewhere, become black, and at this stage, or before, the leaves at the top wither, and the entire cane dries up. Some of the canes only were attacked when sufficiently young to give time for the disease to run its full course, others were attacked at later stages, and are yielding a certain amount of juice. Wherever the fungus has been growing in the cane for a sufficient length of time small, black, minutely velvety spots are to be found among the sleeping roots which look like warts on the nodes. These spots are groups of myriads of spores ready to be distributed by the wind.

Symptoms.

Each garden which I examined showed the disease in all its stages, contained in fact plants which had been attacked at different periods.

Native methods.

3. ***Methods adopted by the ryots which bear upon the spread of the disease.***—The only crop raised in rotation with sugar-cane by most of these ryots is paddy, and it appears to be the general custom to keep a particular plot as a sugar-cane garden for two years to plant paddy in the third year, and then revert to sugar-cane. The sugar-cane crop of the first year is raised by planting "tops." Before the canes are passed through the crushing mill the upper portion with the leaves is cut off; this when trimmed constitutes a "top." The "tops" are put together in a heap loosely covered up with leaves, and are planted out after about four or five weeks, so that they remain exposed to any spores which may be about in the air for a considerable time; during this some of them are doubtless attacked.

Planting of "tops."

If sufficient "tops" are not available, any joint, *i.e.*, any internode with a couple of nodes showing buds, is used.

Treatment of the land.

The land from which paddy has been recently harvested is ploughed, dry, if possible, after soaking if necessary. The "tops" are laid out in rows, trampled in, and after sprouting has begun furrows are made and irrigation commences. The second-year crop is raised by ratooning, *i.e.*, the stools of the previous crop are left in the ground, and new shoots grow from them. If a second year-crop has been very good, a third-year crop is sometimes attempted in the same way, but this does not appear to be the custom, nor, apart altogether from this disease, do the ryots seem to expect a third-year crop to be

Dr. Watt's report.

a good one; the canes, they say, are likely to be thin and without much juice. The ratooning seems, under ordinary circumstances, to give very good results for one year. I may, however, at once point out that where this disease is present, to attempt a second-year crop by this method is not only absolutely suicidal, but helps to spread the disease. Almost all the second-year crops now being cut are worse than the first-year ones, and the stools which are now being left to sprout are, I find, almost all infected, so that next year's crop grown from them are almost sure to be complete failures. I expect the shoots, infected as they will be from the very first, will soon wither.

Precautions.

Canes for chewing.

In most gardens a certain number of canes are cut from day to day and sold for "chewing," and fetch about 2 pies each at the garden. The "chewing" season lasts from about January to March. When the bulk of the canes is ripe a mill is erected in nearly every garden, the cutting commences in earnest, and the crushing goes on day and night, on some gardens at any rate. About ten coolies and six pairs of buffaloes are employed at each mill. The leaves are given to the buffaloes, the "tops" are put aside as described above, the crushed stems are spread out upon the ground to dry, and when dry are used as fuel for the boiling which takes place on the spot. The ash and scum are used as manure, and any fuel unused is stacked. At all the mills I visited the procedure was identical.

Diseases spread by spores.

4. ***The way in which the disease is spread.***—This disease is actually caused by the fungus. Insects may damage some of the canes, the quality of the water, the use of unsuitable manure, or the exhaustion of the soil may cause a weak crop; but it must be clearly understood that, if spores of this fungus enter its tissues, the strongest and healthiest cane will be attacked. It is the spread of the spores of the fungus which we must endeavour to check, and unless this is done, no other measures are likely to have any beneficial result.

Nature of the spores.

The spores are extremely minute, and occur in inconceivable numbers in the little black patches on the surface as well as inside the tissues of every diseased cane. They are capable of being dried up without losing their vitality, and in this condition are blown about by the wind. There is no doubt but that in an infected area spores are constantly settling everywhere in the form of impalpable dust

particles. We have thus to deal with a most insidious foe. The greater portion of the surface of the cane is protected by a hard cuticle, but the spores easily effect an entry at the broken leaf bases, and the attack usually commences here. They also enter at any spot where the surface is injured, or at a hole made by a boring insect, or at a crack caused by exposure to sun or dry wind. Where the fungus exists in a stool or in a planted "top," it will assuredly grow into the young plant which shoots up thence. It is evident that some of the methods adopted by the ryot are calculated to spread the spores as widely as possible, and his method of planting, and more specially of raising a second crop where the disease is prevalent, are almost certain to ensure its recrudescence in an aggravated form.

Dr. Bourne's report.

Insidious nature of the disease.

5. ***Measures which should be adopted.***—All land, which has been under sugar-cane this year, should be sown with paddy, all cane roots which have been left in the ground wherever there has been any disease being taken up and burnt.

Preventive measures.

All the crushed cane and old leaves and other litter should be burnt at once and none stacked for future use. This can easily be done now while the boiling is going on. The ash will be quite harmless and a most valuable manure.

The best plan to adopt where new gardens are being planted, would be to secure "tops" from a perfectly healthy area, but this will not, I think, be feasible this year. The "tops" now at the gardens will have to be used, but they should be carefully examined by cutting across at each end, and any showing red spots in the flesh scrupulously rejected and burnt.

Next year it will be necessary to consider the feasibility of importing seed, or taking other measures, but it is now too late to do so this year.

S.* 176-93.

G. I. C. P. O.—No. 176 R. & A.—15-10-98.—2,225.—H. R.

All communications regarding THE AGRICULTURAL LEDGER should be addressed to the Editor, Dr. George Watt, Reporter on Economic Products to the Government of India, Calcutta.

The objects of this publication (as already stated) are to gradually develop and perfect our knowledge of Indian Agricultural and Economic questions. Contributions or corrections and additions will therefore be most welcome.

In order to preserve a necessary relation to the various Departments of Government, contributions will be classified and numbered under certain series. Thus, for example, papers on Veterinary subjects will be registered under the Veterinary Series; those on Forestry in the Forest Series. Papers of more direct Agricultural or Industrial interest will be grouped according as the products dealt with belong to the Vegetable or Animal Kingdom. In a like manner, contributions on Mineral and Metallic subjects will be registered under the Mineral Series.

This sheet and the title-page may be removed when the subject-matter is filed in its proper place, according to the letter and number shown at the bottom of each page.

NOTICE.

Future issues of this publication placed under either the "Special Veterinary" or "Special Forest Series" will not be included in the annual enumeration. Such papers are printed for Departmental purposes. Their unfortunate inclusion in the system of annual numbering has led recipients of the ordinary issues to think their sets incomplete.

The following pamphlets have already appeared as Special issues, and have not accordingly been furnished to the public:—

1894 . . . Nos. 8, 9, 10, 11, 13 and 15.
1896 . . . No. 8.